Barophilic bacteria

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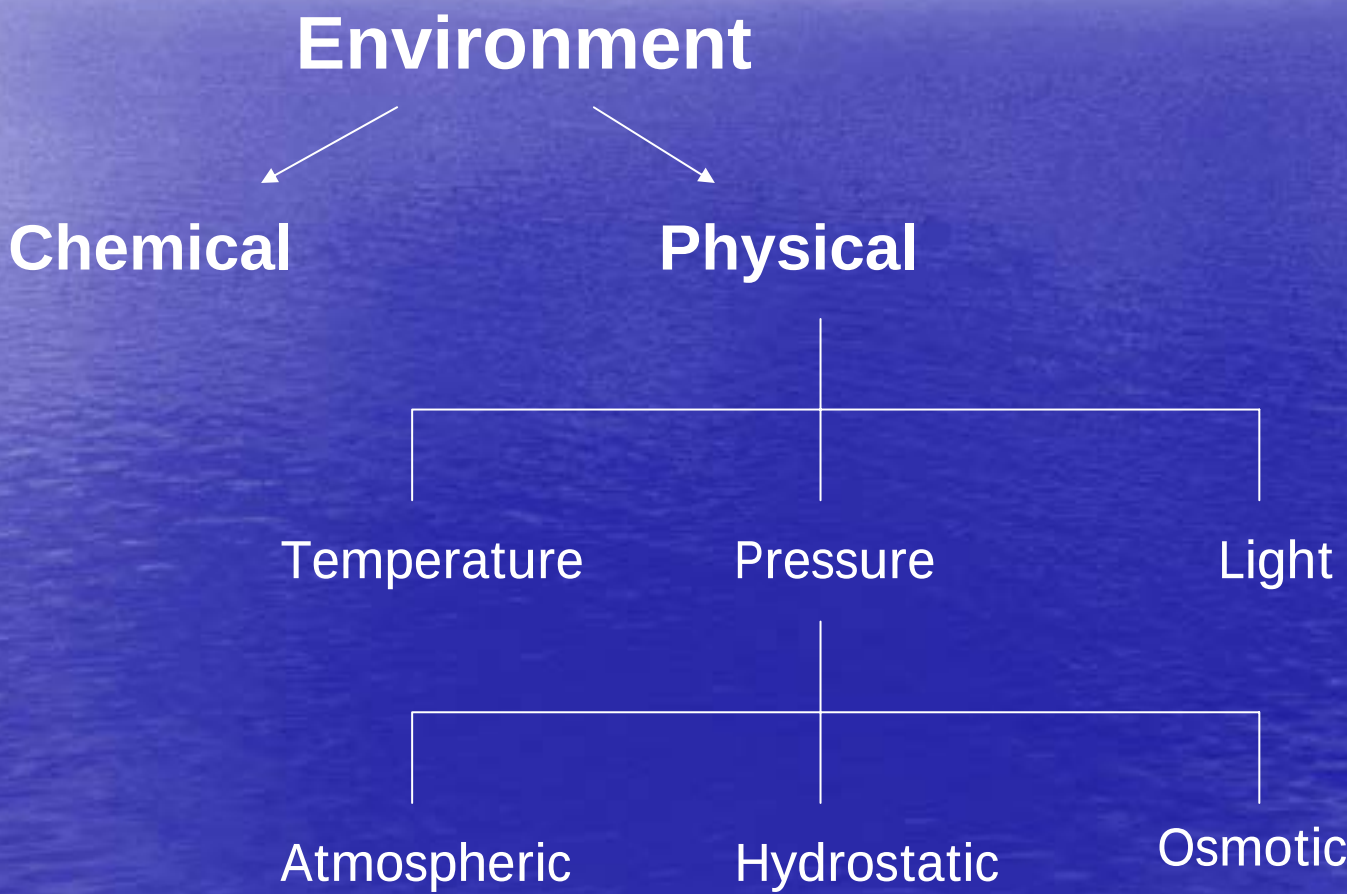
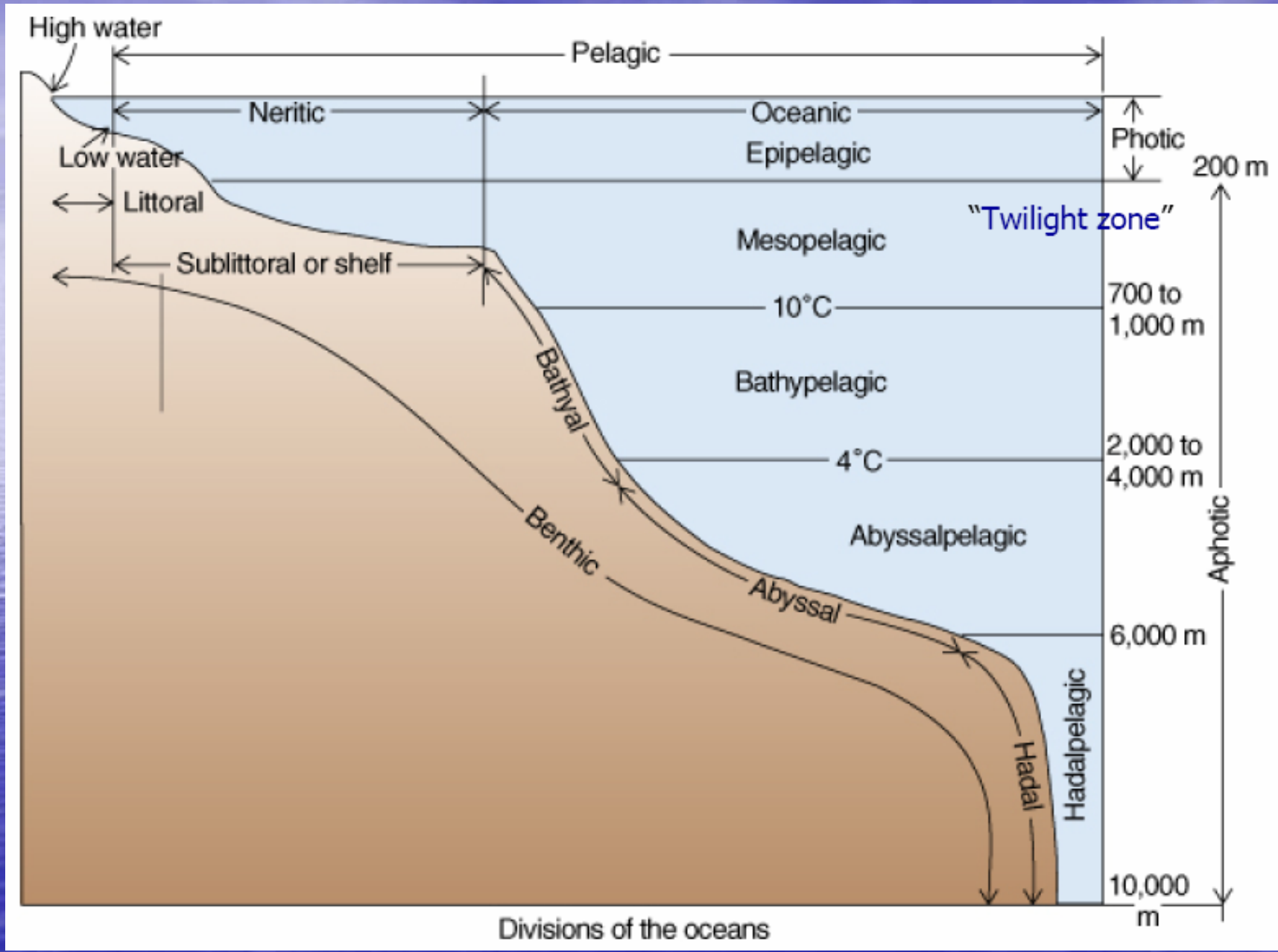
Growth determinants



Hydrostatic pressure

- Unique to deep sea or ocean
- Deep sea constitutes ~62% of oceans biosphere
- Barophils are part of the deep sea biosphere



Divisions of the oceans

Deep sea

Pressures and temperatures of deep sea vary from place to place

Geographic area	Temperature (°C)	Pressure (MPa) (0.101 MPa = 1Atm)
Weddel Basin	-0.5	45.6
Central south pacific	1.2	50.7
Central north pacific	1.5	51
Peru-Chile Trench	1.9	>81
Philippine Trench	2.48	101.7
Mariana Trench	2.46	110.6
Hydrothermal Vent	2 - 380	25
Halmahera Basin	7.54	20.7

Barophils

- The term Barophil is coined by Zobell and Johnson in 1949
- Barophil

  Bacteria which grow preferentially or exclusively at moderately high hydrostatic pressures
- Barophilic bacteria / = Piezophilic bacteria
- The term Piezophily is coined by Yayonas

Barophilic Bacteria

- Barotolerants (facultative)

  Grows at pressures from 100 – 500 Atm
- Barophilic (obligative)

  Grows at pressure from 400 – 500 Atm
- Extreme Barophilic

  Grows at pressures higher than 500 Atm

Examples of Barophilic bacteria

Bacteria	Temperature (°C)	Pressure (MPa)
Colwellia MT41	8	103
Strain MT 199	13	90
Strain PT 64	9	90
Shewenella SC2A	20	14
Photobacterium profundum DSJ4	10	10
Moritella PE36	15	41
Moritella Japonica DSK1	15	50
Schewenella Benthica	5	40

Adaptations to high pressure

- Increased binding capacity of enzymes
- Poly unsaturated fatty acids in membranes
- Pressure controlled gene expression

Scope of studying the Barophilic bacteria

- To determine the bounds of where life can exist
- To determine the properties of organisms that have evolved at particular values of temperature and pressure
- To guide future searches for extraterrestrial life beneath the surface of other planets
- Bacteria and enzymes can be applied to problems in
  - Analytical chemistry
  - Fermentation technology
  - Bioremediation
  - Waste disposal methodology
  - Biotechnology

Mediterranean Basin

Mediterranean Basin

Mediterranean Sea

- 2.5 million km^2
- average depth of 1,500 m
- deepest recorded point is 5,267 m
- > 80% below 200 m
- abyssal plains ~ 3000 m

Characteristics:

- hypersaline
- anoxic
- high hydrostatic pressure

Mediterranean Basin

Prokaryotic cells are present in the brines

BUT

little is know about their physiological status

Mediterranean Basin

"Microbial Enzymes Mined from the Urania Deep-Sea Hypersaline Anoxic Basin" *(**M. Ferrer** et al, 2005)*

Department of Microbiology

German Research Centre for Biotechnology

Braunschweig

Mediterranean Basin

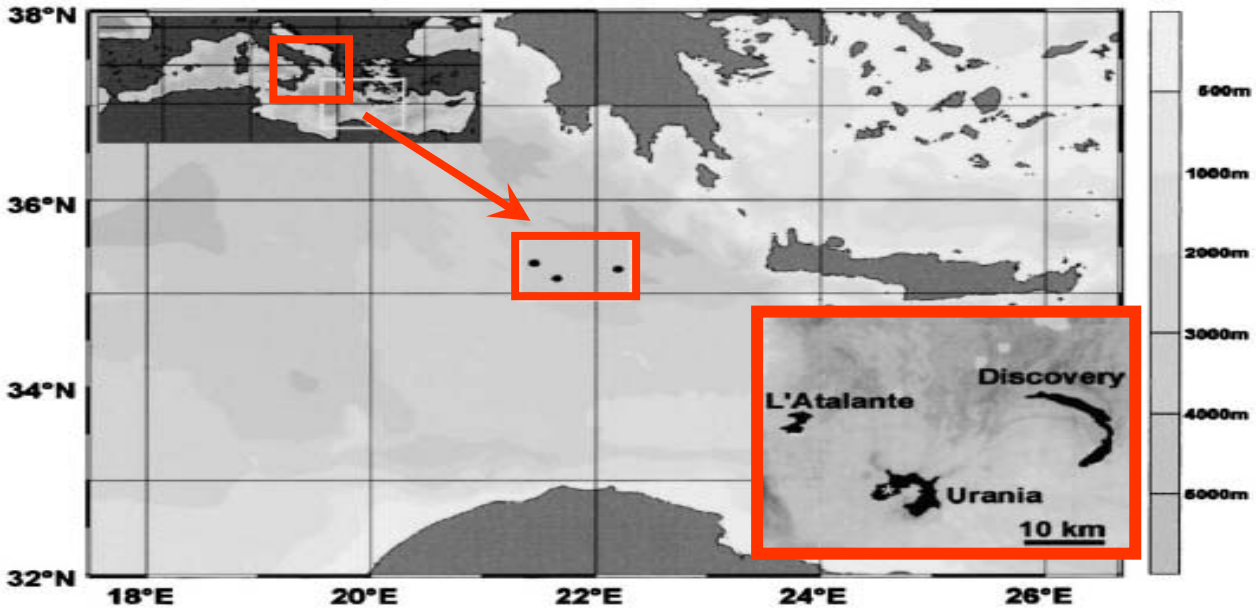


Figure 1. Location of Three Deep Anoxic Hypersaline Basins in the Eastern Mediterranean Sea
The map was constructed with Ocean Data View software [31]. The detailed map of basin profiles is shown in the inset map (bottom right). The sampling site (35°13′51″N; 21°28′24″E; 3552 m depth) is shown by a white asterisk.

Mediterranean Basin

Microbial Enzymes Mined from the Urania Deep-Sea Hypersaline Anoxic Basin *(**M. Ferrer** et al, 2005)*

Scientific approach:

Is there new enzymatic diversity?

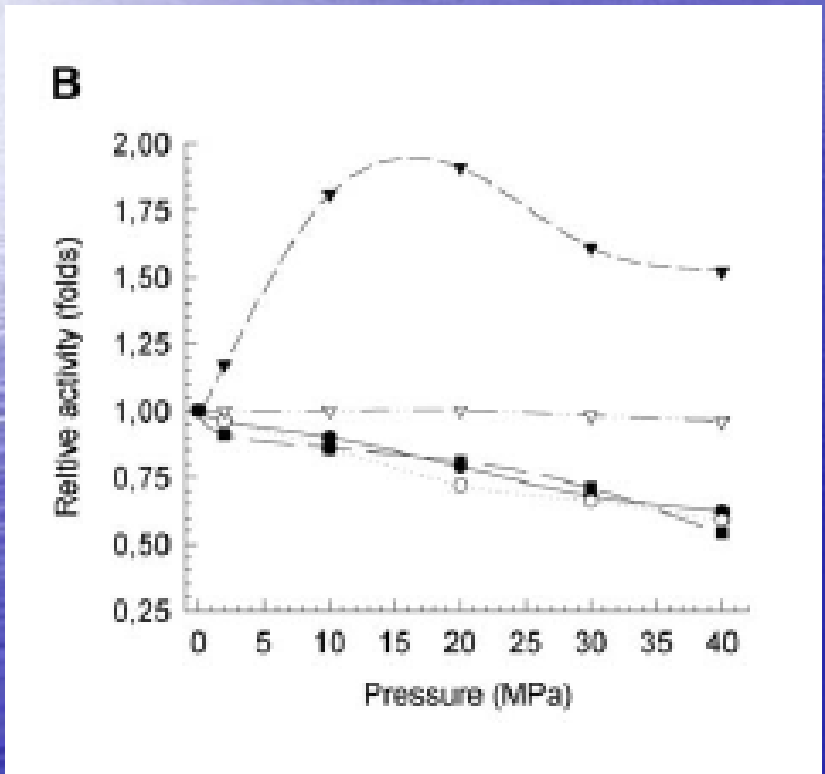
Mediterranean Basin

Method

- sampling
- incubation
- DNA extraction
- esterase genes expressed in E. coli
- characterisation

Mediterranean Basin

Effect of pressure on esterase activity

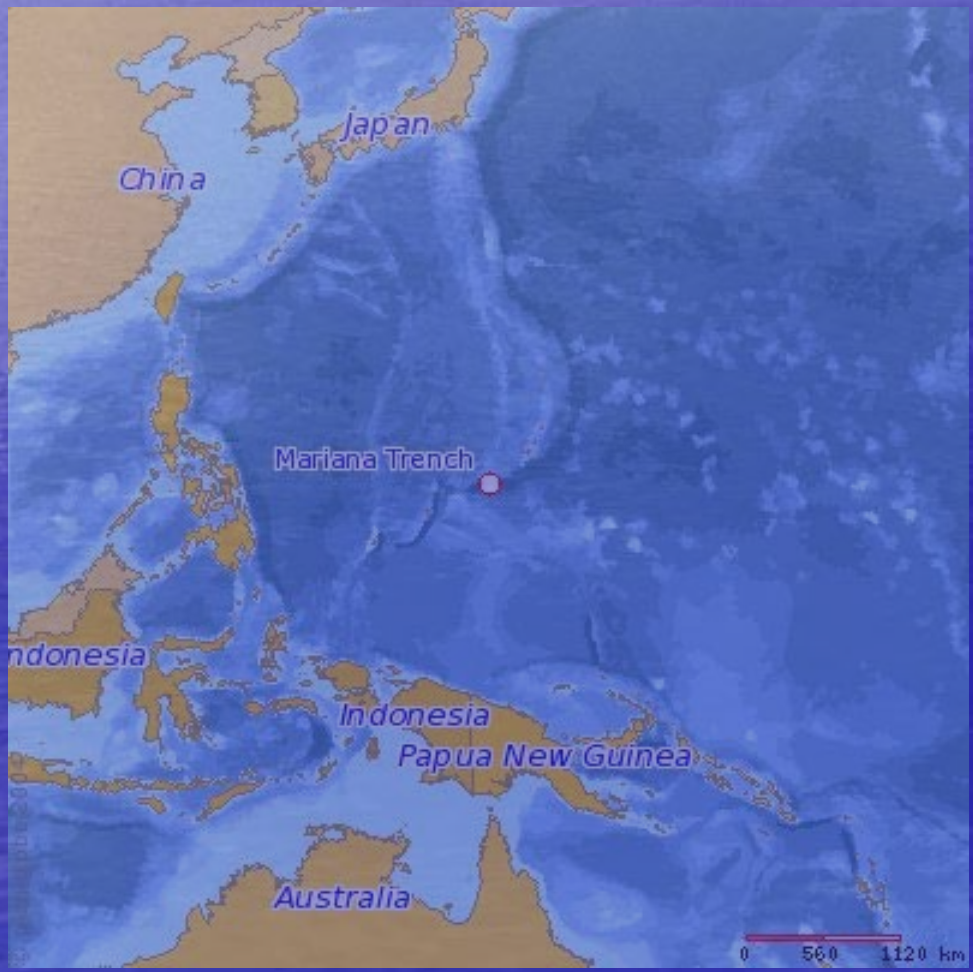


Ferrer M. et al :*Microbial Enzymes Mined from the Urania Deep-Sea Hypersaline Anoxic Basin*. Chemistry and Biology, Vol. 12, 2005.

Results:

- esterases inactivated or
- not affected or
- activity increased

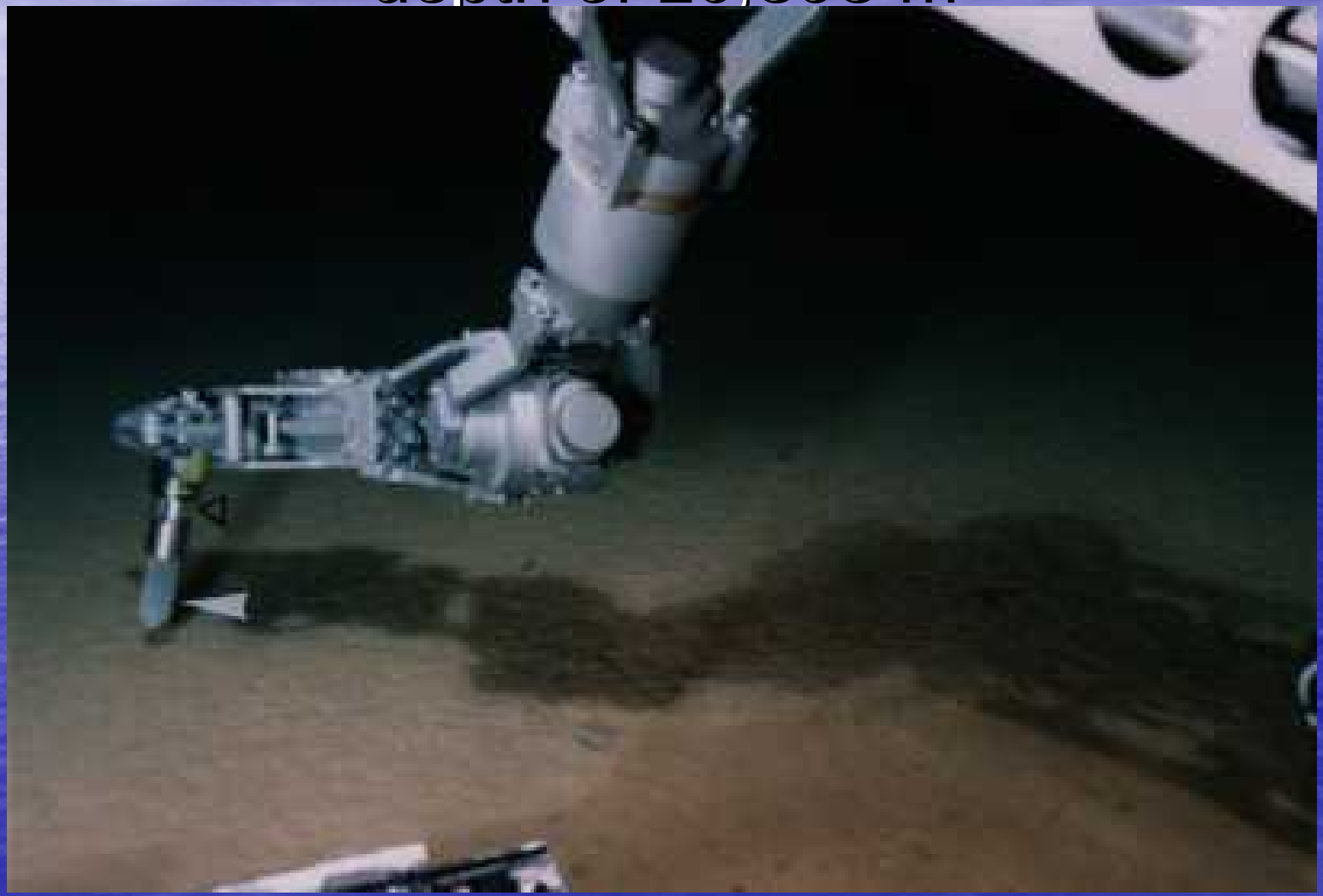
Extremely Barophilic Bacteria Isolated From The Mariana Trench



Pressure increases with one atmosphere for about every 10 meters (one atmosphere is 101,325 Pa; one bar is exactly 100,000 Pa).

Water pressure at the bottom over 1000 atm, that's over one metric tonne per square centimeter.

Unmanned Deep-Sea submersible Kaiko In The Mariana Trench, Challenger Deep, at a depth of 10,898 m



DB21MT-2

DB21MT-5

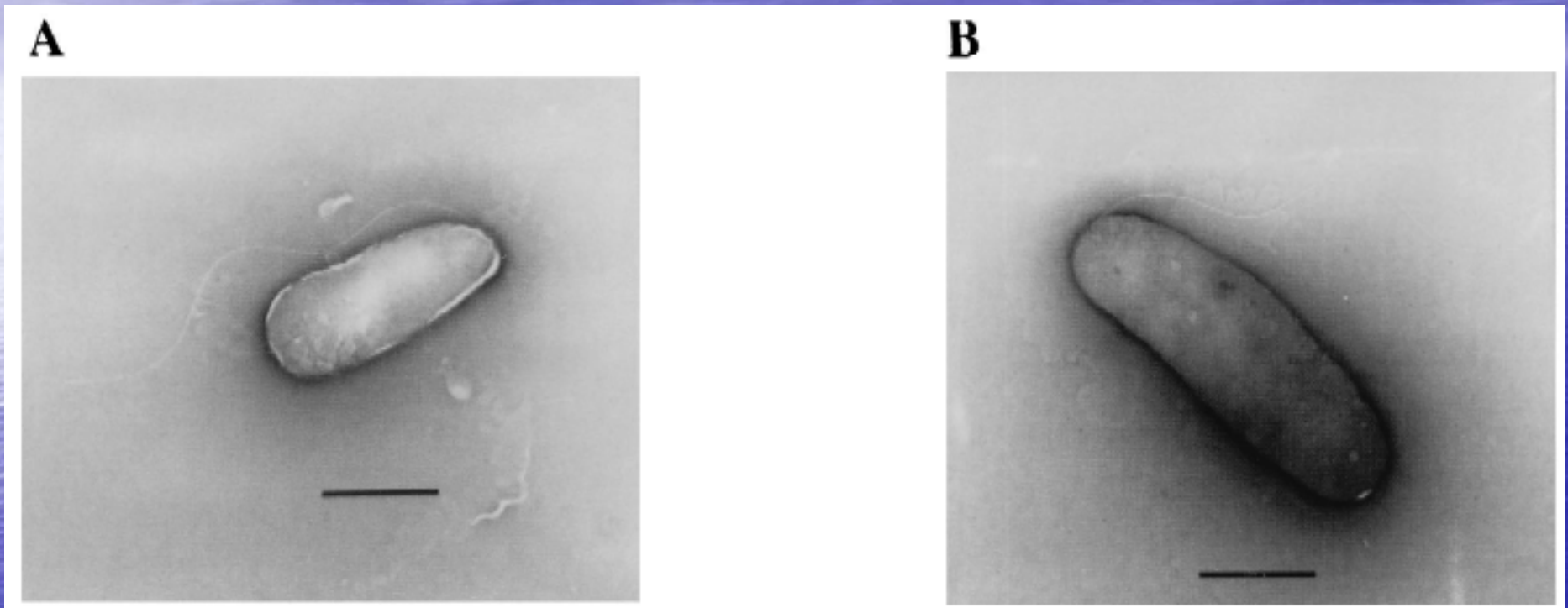


FIG. 2. Electron micrographs (negative staining) of extreme-barophile bacteria (strains DB21MT-2 [A] and DB21MT-5 [B]). Bar, 1 μm.

Two strains of obligately barophilic bacteria in the world‘s deepest sediment

DB21MT-2

- **highly similar to *Shewanella benthica***

DB21MT-5

- **closely related to the genus *Moritella***

Optimal pressure conditions for growth

- ***70 MPa***
- ***80 MPa***

!!! No growth at pressures of less than 50 MPa !!!

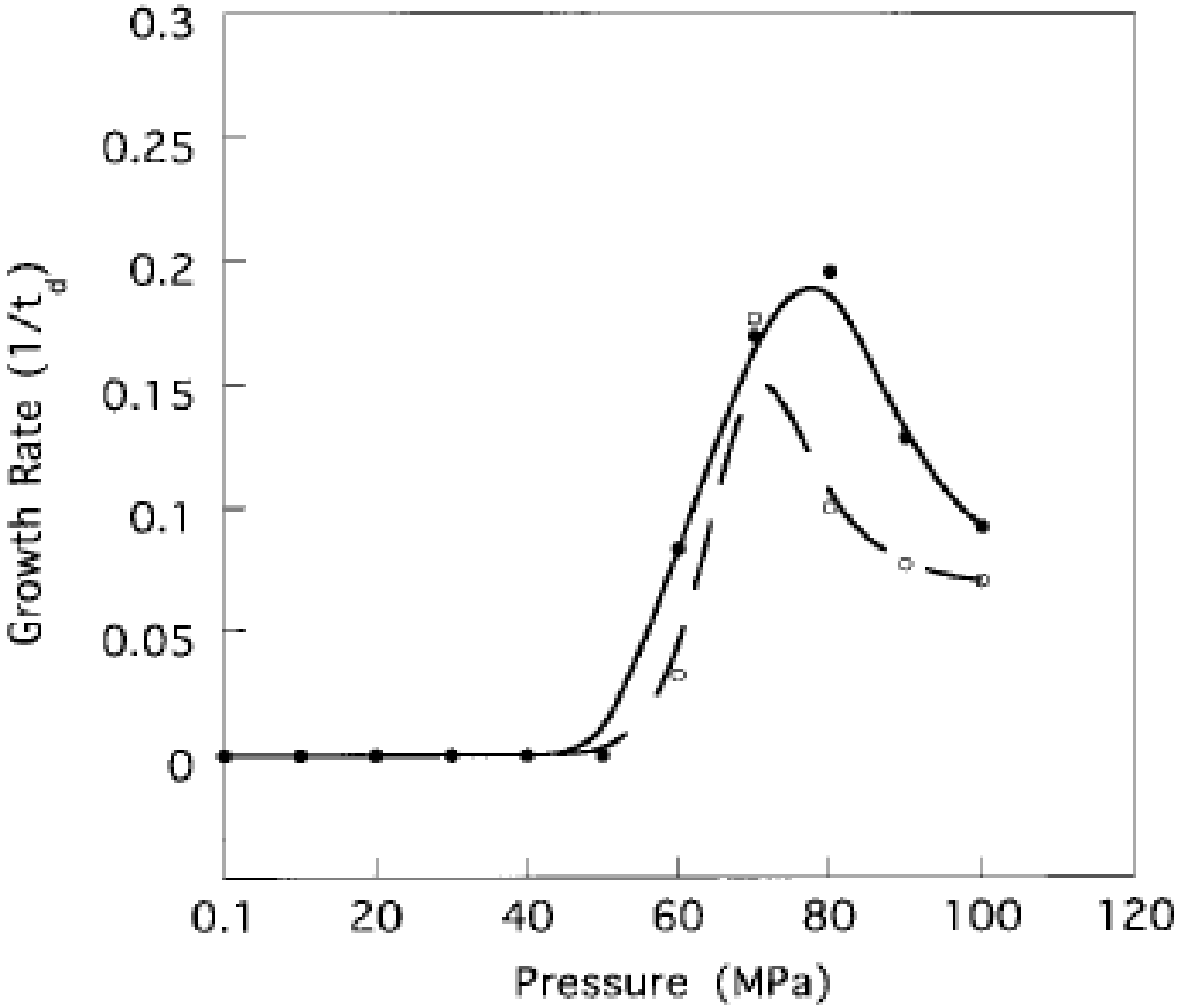
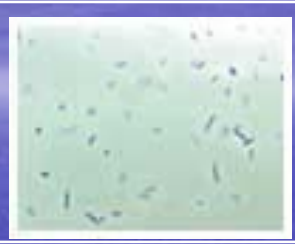


FIG. 3. Growth properties of the extreme barophiles at elevated hydrostatic pressure. Dotted line, DB21MT-2; solid line, DB21MT-5. t_d, doubling time (in hours).

The photo compares morphological changes of piezophilic bacterium and Escherichia coli.
Escherichia coli live well under atmospheric pressure,
but under higher pressure they do not proliferate well, and the cell elongates.
Piezophilic bacterium grows better as pressure increases.
The pressures of 100 atms. and 500 atms. correspond to those at 1,000 meters depth and 5,000 meters depth of water, respectively.

Piezophilic bacterium	Escherichia coli	
		Atmospheric pressure
		100 atms.
		300 atms.
		500 atms.